



**Marine Sediment Characterisation
Kilrush Approach Channel
Dredging and Disposal Operations**

Produced by

AQUAFAC International Services Ltd

For

Kilrush Marina

May 2023

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Table of Contents

1. Introduction.....	3
2. Materials & Methods.....	3
2.1. Sample Processing.....	3
2.2. Sample Processing.....	5
2.2.1. <i>Particle Size Analysis (PSA)</i>	5
2.2.2. <i>Moisture Content & Density</i>	6
2.2.3. <i>Chemical Analysis</i>	6
3. Physical / Chemical Results	6
3.1. Sediment Description.....	7
3.2. Sediment Physical Attributes	7
3.3. Metals	8
3.4. Organochlorines	10
3.5. Extractable Hydrocarbon	11
3.6. Organotins	11
3.6.1. <i>PAH</i>	11
4. Discussion/Conclusion	13
5. References	13

List of Figures

Figure 2.1: Location of chemistry sampling sites	4
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List of Tables

Table 2.1: Coordinates of stations sampled for physical and chemical analysis.....	4
Table 2.2: Limits of Detection	6
Table 3.1: Visual Inspection	7
Table 3.2: Moisture content.....	7
Table 3.3: Granulometry results.....	8
Table 3.4: Total organic carbon results.....	8
Table 3.5: Metal results.	9
Table 3.6: Proposed metal guidance values for sediment quality guidelines (Cronin <i>et al.</i> , 2006, & Marine Institute, 2019).	9
Table 3.7: Organochlorine results.	10
Table 3.8: PCB Results.	10
Table 3.9: Proposed organochlorine and PCB guidance values for sediment quality guidelines (Cronin <i>et al.</i> , 2006).	10
Table 3.10: Total extractable hydrocarbon results.	11
Table 3.11: Dibutyl and tributyl tin results.	11
Table 3.12: PAH results.	12

List of Appendices

Appendix 1:	EPA Sediment Analysis Requirement
Appendix 2:	Annex 1 Action Level Results

1. Introduction

Kilrush Marina is applying to the EPA for a Dumping at Sea Licence to carry out dredging along the channel leading up to sea gate at the entrance to Kilrush Marina.

AQUAFAC International Services Ltd. was commissioned by Kilrush Marina to carry out a marine sediment characterisation survey of the dredge area.

2. Materials & Methods

2.1. Sample Processing

On the 23rd March 2023, 4 sediment stations were sampled for physical and chemical analysis as per the dumping at sea permit issued by the EPA to Kilrush Marina (see Appendix 1). Sampling and analysis were conducted in accordance with the analytical and quality requirements set out in the guidelines for the assessment of dredge material for disposal in Irish waters (Cronin *et al.*, 2006). Figure 2.1 shows the station locations as recommended by the Marine Institute in 2016 and Table 2.1 presents the station coordinates.

One grab sample was taken at each of the stations and the samples were divided as follows:

1. Into labelled 1l plastic bags for water content, density and sediment grain size analysis;
2. Into 120ml amber glass jars for organochlorine, PCB (polychlorinated biphenyl), PAH (polycyclic aromatic hydrocarbon), total extractable hydrocarbon, TBT (tributyl tin) and DBT (dibutyl tin) analysis;
3. Into 500ml plastic pots for metal, total organic carbon and carbonate analysis.



Figure 2.1: Location of chemistry sampling sites

Table 2.1: Coordinates of stations sampled for physical and chemical analysis.

Sample_No.	Longitude_W	Latitude_N
1	-9.50378	52.62678
2	-9.50367	52.62982
3	-9.50267	52.63198
4	-9.50438	52.63209

2.2. Sample Processing

Once back in the lab, all sediment samples for the analysis of organics and contaminants were sent to the SOCOTEC Laboratories in Burton on Trent. AQUAFACt carried out the particle size analysis and moisture and density content as described below.

2.2.1. Particle Size Analysis (PSA)

AQUAFACt carried out the PSA analysis in-house using the following methodology:

1. Approximately 100g of dried sediment (previously washed in distilled water and dried) was weighed out and placed in a labelled 1L glass beaker to which 100ml of a 6 percent hydrogen peroxide solution was added. This was allowed to stand overnight in a fume hood.
2. The beaker was placed on a hot plate and heated gently. Small quantities of hydrogen peroxide were added to the beaker until there was no further reaction. This peroxide treatment removed any organic material from the sediment which can interfere with grain size determination.
3. The beaker was then emptied of sediment and rinsed into a 63µm sieve. This was then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve was then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution was added to the beaker and this solution was stirred for ten minutes and then allowed to stand overnight. This treatment helped to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution was washed and rinsed into a 63µm sieve. The retained sample was carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100°C for 24 hours.
6. The dried sediment was then passed through a Wentworth series of analytical sieves (>8,000 to 63µm; single phi units). The weight of material retained in each sieve was weighed and recorded. The material which passed through the 63µm sieve was also weighed and the value added to the value measured in Point 5 (above).
7. The total silt/clay fraction was determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63µm fraction was lost during the various washing stages.
8. The following range of particle sizes: <63µm, 63<125µm, 125<250µm, 250<500µm, 500<1000µm, 1000<2000µm, 2000<4000µm and 4000<8000µm were reported.

2.2.2. Moisture Content

Moisture content was taken as the percentage weight difference between the wet and dried sediment.

2.2.3. Chemical Analysis

The following methodologies were employed by SOCOTEC Burton-upon-Trent:

- Total Solids: Calculation (100%-Moisture Content). Moisture content determined by drying a portion of the sample at 120°C to constant weight.
- Total Hydrocarbons: Solvent extraction and clean up followed by GC-FID analysis.
- Organotins: Solvent extraction and derivatisation followed by GC-MS analysis.
- Metals: Aqua-regia extraction followed by ICP analysis.
- PAH analysis: Solvent extraction and clean up followed by GC-MS analysis.

All tests were carried out on the <2mm fraction.

The Limits of detection can be seen in Table 2.2.

Table 2.2: Limits of Detection

Parameter	Unit	LOD
Hydrocarbons	µg/kg	100
Mercury	mg/kg	0.01
Aluminium	mg/kg	1750
Arsenic	mg/kg	0.14
Cadmium	mg/kg	0.03
Chromium	mg/kg	1
Copper	mg/kg	0.7
Lead	mg/kg	0.6
Lithium	mg/kg	2
Nickel	mg/kg	0.4
Zinc	mg/kg	3.5
OCP	µg/kg	0.1
PAH	µg/kg	1
PCBs	µg/kg	0.08
DBT/TBT	µg/kg	1

3. Physical / Chemical Results

The results of the physical and chemical analysis are included as Appendix 2.

3.1. Sediment Description

Table 3.1 shows the visual inspection information, which includes colour and sediment type.

Table 3.1: Visual Inspection

Station	Description	
Kil 1	Brown fine sand, black underlayer	
Kil 2	Brown clean fine sand	
Kil 3	Black sticky mud	
Kil 4	Black sticky mud	

3.2. Sediment Physical Attributes

The water content results can be seen in Table 3.2. Values ranged from 35.1 (S4) to 48.7% (S3) for moisture content.

Table 3.2: Moisture content

Station	Moisture Content (%)
Kil 1	38.0
Kil 2	41.7
Kil 3	48.7

Station	Moisture Content (%)
Kil 4	35.1

Table 3.3 shows the granulometry results broken down into % gravel (>2mm), sand (<2mm >63µm) and silt-clay (<63µm). Gravel ranged from 13.4% (Kil 2) to 91.3% (Kil 3), sand ranged from 5.6% (Kil 3) to 75.3% (Kil 2) and silt-clay ranged from 3% (Kil 3) to 13.5% (Kil 1).

Table 3.3: Granulometry results

Station	% Gravel (>2mm)	% Sand (<2mm - > 63µm)	% Silt-Clay (<63µm)
Kil 1	25.4	61.1	13.5
Kil 2	13.4	75.3	11.3
Kil 3	91.3	5.6	3
Kil 4	69.2	24.6	6.2

Table 3.4 shows the total organic carbon and carbonate results. TOC values ranged from 0.91% (Kil 2) to 1.69% (Kil 3) while carbonate ranged from 6.7% (Kil 4) to 23.5% (Kil 1).

Table 3.4: Total organic carbon results

Station	TOC %	Carbonate%
Kil 1	1	23.5
Kil 2	0.91	21.6
Kil 3	1.69	13.7
Kil 4	1.06	6.7

3.3. Metals

Table 3.5 shows the metal results. Mercury (Hg) levels ranged from <0.01 (Kil 3) to 0.04 mg/kg (Kil 2 & 4). Aluminium (Al) levels ranged from 22,700 (Kil 2) to 66,700mg/kg (Kil 4). Arsenic (As) levels ranged from 9.5 (Kil 2) to 14.5mg/kg (Kil 3). Cadmium (Cd) levels ranged from 0.26 (Kil 2) to 0.39 mg/kg (Kil 3). Chromium (Cr) levels ranged from 28.7 (Kil 2) to 100mg/kg (Kil 4). Copper (Cu) levels ranged from 6.3 (Kil 2) to 44.2mg/kg (Kil 3). Results for Lithium (Li) levels ranged from 19.8 (Kil 2) to 59.8mg/kg (Kil 4). Lead (Pb) levels ranged from 10.9 (Kil 2) to 60.0mg/kg (Kil 4). Nickel (Ni) levels ranged from 13.8 (Kil 2) to 40.3mg/kg (Kil 4). Zinc (Zn) levels ranged from 44.6 (Kil 1) to 360.0mg/kg (Kil 4).

The guidance values for metals (Cronin *et al.*, 2006 and Marine Institute addendum (Marine Institute, 2019)) can be seen in Table 3.6 below. Apart from copper, nickel and zinc, all heavy metals were below the lower level guidance values. A value of 44.2 mg/kg for copper recorded at Station Kil 3 is above the lower limit of 40 mg/kg but below the upper limit of 110 mg/kg. A value of 60.0 mg/kg for lead recorded at Station Kil 4 was just within the lower limit of 60 as recommended. A value of 40.3 mg/kg for Nickel was recorded at station Kil 4. This value is marginally above the lower limit of 40mg/kg but below the upper levels of 60 as recommended (Marine Institute addendum, 2019). Values of 224 and 360 mg/kg for Zinc were recorded at stations Kil 3 & Kil 4 respectively. These values are above the lower limit of 160mg/kg but below the upper levels of 410 as recommended.

Table 3.5: Metal results.

Station	Hg mg/kg	Al mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Li mg/kg	Pb mg/kg	Ni mg/kg	Zn mg/kg
Kil 1	0.03	23000	10.1	0.3	29.7	6.7	20.2	11.9	14.7	45.4
Kil 2	0.04	22700	9.5	0.26	28.7	6.3	19.8	10.9	13.8	44.6
Kil 3	<0.01	48600	14.5	0.39	60.6	44.2	40.4	47.8	29.7	224
Kil 4	0.04	66700	12.6	0.32	100	37.3	59.8	60.0	40.3	360

Table 3.6: Proposed metal guidance values for sediment quality guidelines (Cronin *et al.*, 2006, & Marine Institute, 2019).

Metal	Lower level	Upper Level
As (mg/kg)	20	70 [#]
Cd (mg/kg)	0.7	4.2
Cr (mg/kg)	120	370
Cu (mg/kg)	40	110 [^]
Pb (mg/kg)	60	218
Hg (mg/kg)	0.2	0.7
Ni (mg/kg)	40	60
Zn (mg/kg)	160	410

[#] In some locations natural levels of arsenic will exceed this value and in such instances this guidance value will not be appropriate.

[^] PEL as ERM considered high

3.4. Organochlorines

Tables 3.7 and 3.8 show the organochlorines and PCB results. All organochlorines tested for were <0.1µg/kg apart from DDT at station Kil 3 which measured 0.160.1µg/kg. PCB's ranged from <0.08µg/kg (majority) to 0.15 µg/kg (PCB 052, Kil 3) & 0.22 µg/kg (PCB 028, Kil 3).

The guidance values for organochlorines and PCBs (Cronin *et al.*, 2006) can be seen in Table 3.9 below and all results are below the lower guidance levels.

Table 3.7: Organochlorine results.

Station	DDE-pp ug/kg	DDT- pp ug/kg	Dieldrin ug/kg	HCH Alpha ug/kg	HCH Beta ug/kg	HCH Gamma ug/kg	HCB ug/kg	DDD-pp ug/kg
Kil 1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Kil 2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Kil 3	<0.1	0.16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Kil 4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 3.8: PCB Results.

Station	PCB 028 ug/kg	PCB 052 ug/kg	PCB 101 ug/kg	PCB 118 ug/kg	PCB 138 ug/kg	PCB 153 ug/kg	PCB 180 ug/kg
Kil 1	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Kil 2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Kil 3	0.22	0.15	<0.08	<0.08	<0.08	<0.08	<0.08
Kil 4	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08

Table 3.9: Proposed organochlorine and PCB guidance values for sediment quality guidelines (Cronin *et al.*, 2006).

Parameter	Lower level	Upper Level
γ-HCH (Lindane) (µg/kg)	0.3	1
HCB (µg/kg)	0.3	1
PCB (individual congeners of ICES 7) (µg/kg)	1	180
PCB (Σ ICES 7) (µg/kg)	7	1260

3.5. Extractable Hydrocarbon

Table 3.10 presents the total extractable hydrocarbon results. Values ranged from 14.7 mg/kg (Kil1) to 64.1 mg/kg (Kil 3). These values are below the lower guidance level of 1000 mg/kg (1 g/kg) (Cronin *et al.*, 2006).

Table 3.10: Total extractable hydrocarbon results.

Station	Hydrocarbons mg/kg
Kil 1	14.7
Kil 2	16.9
Kil 3	64.1
Kil 4	41.7

3.6. Organotins

Table 3.11 shows the dibutyl and tributyl tin results. The results for DBT and TBT were all <0.005 mg/kg at the four sampled stations. The guidance values for the sum of TBT and DBT range from a lower level of 0.1 to an upper level of 0.5mg/kg (Cronin *et al.*, 2006). All values are below the lower limit.

Table 3.11: Dibutyl and tributyl tin results.

Station	DBT µg/kg	TBT µg/kg
Kil 1	<5	<5
Kil 2	<5	<5
Kil 3	<5	<5
Kil 4	<5	<5

3.6.1. PAH

Table 3.12 shows the PAH results.

The lower level guidance values for the sum of all 16 PAHs is 4000 µg/kg (Cronin *et al.*, 2006). All stations were below this lower limit.

Table 3.12: PAH results.

Sample Number	Kil 1	Kil 2	Kil 3	Kil 4
PAH Acenaphthene ug/kg	2.08	1.30	15.3	10.9
PAH Acenaphthylene ug/kg	1.08	<1	<5	27.5
PAH Anthracene ug/kg	6.04	2.72	64.2	81.2
PAH Benzo a anthracene ug/kg	11.4	14.9	149	90.0
PAH Benzo (a) pyrene ug/kg	13.1	18.6	148	68.6
PAH Benzo (b) fluoranthene ug/kg	14.3	17.7	113	50.4
PAH Benzo ghi perylene ug/kg	11.0	13.4	74.1	31.9
PAH Benzo k fluoranthene ug/kg	12.0	17.4	133	61.3
PAH Chrysene ug/kg	13.6	16.8	160	86.1
PAH Dibenzo a,h anthracene ug/kg	1.82	2.71	21.4	<5
PAH Fluoranthene ug/kg	29.8	27.6	255	190
PAH Fluorene ug/kg	3.36	1.70	25.1	43.3
PAH Indeno 1,2,3 – cd pyrene ug/kg	10.7	14.3	89.2	34.2
PAH Naphthalene ug/kg	4.16	5.39	<5	7.75
PAH Phenanthrene ug/kg	20.8	8.96	188	195
PAH Pyrene ug/kg	25.3	25.7	199	152

4. Discussion/Conclusion

The value for copper was above the lower limit for stations Kil 3 the value for Nickel was above the lower limit for station Kil 4, and the value for Zinc was above the lower level for stations Kil 3 & 4 respectively. All the sediments were below the Upper Irish action limits for metals, organochlorines, PCBs, total extractable hydrocarbons, organotins and $\Sigma 16$ PAH's (see Appendix 2 for Annex 1 action level limits table).

The suitability of the spoil for disposal at sea will be determined by the EPA.

5. References

- Cronin, M., McGovern, E., McMahon, T. & R. Boelens. 2006. Guidelines for the assessment of dredge material for disposal in Irish waters. Marine Environmental and Health Series, No. 24, 2006.
- Marine Institute, (2019). Addendum to 2006 Guidelines for the Assessment of Dredged material in Irish Waters (Cronin et al.).

Appendix 1

Kilrush Dumping At Sea Permit

Appendix 2
Annex 1 Action Level Limits

ANNEX 1: TABLES

Table B.1 Results of sediment chemistry analysis of the material to be dumped at sea, with reference to Irish Action Levels ^{Note 1}

Parameter	Units (dry wt) ^{Note 2}	Lower Action Limit	Upper Action Limit				
				Kil 1	Kil 2	Kil 3	Kil 4
Arsenic	mg kg ⁻¹	20	70	10.1	9.5	14.5	12.6
Cadmium	mg kg ⁻¹	0.7	4.2	0.3	0.26	0.39	0.32
Chromium	mg kg ⁻¹	120	370	29.7	28.7	60.6	100
Copper	mg kg ⁻¹	40	110	6.7	6.3	44.2	37.3
Lead	mg kg ⁻¹	60	218	11.9	10.9	47.8	60
Mercury	mg kg ⁻¹	0.2	0.7	0.03	0.04	<0.01	0.04
Nickel	mg kg ⁻¹	40	60	14.7	13.8	29.7	40.3
Zinc	mg kg ⁻¹	160	410	45.4	44.6	224	360
Σ TBT & DBT ^{Note 3}	mg kg ⁻¹	0.1	0.5	<0.01	<0.01	<0.01	<0.01
γ-HCH (Lindane) ^{Note 4}	μg kg ⁻¹	0.3	1	<0.1	<0.1	<0.1	<0.1
HCB ^{Note 5}	μg kg ⁻¹	0.3	1	<0.1	<0.1	<0.1	<0.1
PCB (individual congeners of ICES 7) ^{Note 6}	μg kg ⁻¹	1	180	<0.08	<0.08	0.22	<0.08
PCB 028	μg kg ⁻¹			<0.08	<0.08	0.15	<0.08
PCB 052	μg kg ⁻¹			<0.08	<0.08	<0.08	<0.08
PCB 101	μg kg ⁻¹			<0.08	<0.08	<0.08	<0.08
PCB 118	μg kg ⁻¹			<0.08	<0.08	<0.08	<0.08
PCB 138	μg kg ⁻¹			<0.08	<0.08	<0.08	<0.08
PCB 153	μg kg ⁻¹			<0.08	<0.08	<0.08	<0.08
PCB 180	μg kg ⁻¹			<0.08	<0.08	<0.08	<0.08
PCB (Σ ICES 7) ^{Note 6}	μg kg ⁻¹	7	1260	<0.56	<0.56	<0.77	<0.56
PAH (Σ 16) ^{Note 7}	μg kg ⁻¹	4000		180.54	189.18	1634.3	1130.15
Total Extractable Hydrocarbons	g kg ⁻¹	1.0		0.0147	0.0169	0.0641	0.0417

Exceed Upper Irish Action Limit

Note 1: Applicants should highlight in Table B.1 any results which exceed either the upper or lower Irish action levels. Action levels are published in: *Cronin et al. 2006. Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute and Marine Institute, (2019). Addendum to 2006 Guidelines for the Assessment of Dredged material in Irish Waters (Cronin et al.).*

Note 2: Total sediment <2 mm

Note 3: Sum of tributyl tin and dibutyl tin

Note 4: 1α,2α,3β,4α,5α,6β-hexachlorocyclohexane

Note 5: Hexachlorobenzene

Note 6: ICES 7 polychlorinated biphenyls: PCB 28, 52, 101, 118, 138, 153, 180.

Note 7: Polyaromatic hydrocarbons (measured as individual compounds): Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.

